Notice No.2

Rules and Regulations for the Application of Sandwich Panel Construction to Ship Structure July 2020

The status of this Rule set is amended as shown and is now to be read in conjunction with this and prior Notices. Any corrigenda included in the Notice are effective immediately.

Please note that corrigenda amends to paragraphs, Tables and Figures are not shown in their entirety.

Issue date: June 2021

Amendments to	Effective date	IACS/IMO implementation (if applicable)
Chapter 1, Sections 1, 2, 3, 4 & 6	Corrigendum	N/A
Chapter 2, Sections 1, 2, 3 & 5	Corrigendum	N/A
Chapter 3, Sections 1, 2, 3, 4 & 7	Corrigendum	N/A

Lloyd's Register

Chapter 1
General

■ *Section 1*
Application

1.1 Application

1.1.1 These *Rules for the Application of Sandwich Panel Construction to Ship Structure* ~~(hereinafter referred to as the Sandwich Construction Rules)~~ set down the criteria for the assessment of ship structures constructed using steel sandwich panels, *see Ch 1, 2.2 Steel Sandwich Panel definition*, and are applied in addition to other relevant requirements of the *Rules and Regulations for the Classification of Ships* ~~(hereinafter referred to as the Rules for Ships)~~.

All instances of Rules for Ships have been replaced with Rules and Regulations for the Classification of Ships throughout this Ruleset.

1.1.2 ~~The Sandwich Construction Rules~~ These Rules are in general applicable to mono hull ships of normal form, proportions and speed constructed in whole or partly using sandwich construction.

1.1.3 Ships of unusual form, proportions, speed, or intended for the carriage of special cargoes, or for special or restricted service, not covered by *Pt 3 Ship Structures (General)* and *Pt 4 Ship Structures (Ship Types)* of the ~~Rules for Ships~~ *Rules and Regulations for the Classification of Ships*, will receive individual consideration based on the general standards of the ~~Sandwich Construction Rules~~ *Rules for the Application of Sandwich Panel Construction to Ship Structure* (*see also Ch 1, 1.5 Special application*).

1.1.4 It is assumed in ~~the Sandwich Construction Rules~~ these Rules that the material of construction for the top and bottom plating of the sandwich panel is steel according to the *Rules for the Manufacture, Testing and Certification of Materials* (~~hereinafter referred to as the Rules for Materials)~~.

All instances of Rules for Materials have been replaced with Rules for the Manufacture, Testing and Certification of Materials throughout this Ruleset.

1.1.5 Scantlings of structures constructed of aluminium are to be on the basis of equivalent scantlings as set out in *Pt 3, Ch 2, 1.3 Aluminium* of the ~~Rules for Ships~~ *Rules and Regulations for the Classification of Ships*. In general, for welded structure, the maximum value for the strength of the material, ~~σ_a~~ σ_a, to be used in the scantling derivation is that of the aluminium alloy in the welded condition, where ~~σ_a~~ σ_a is defined as the 0,2 per cent butt welded proof stress or 70 per cent of the ultimate strength of the material in the welded condition in N/mm^2, whichever is the lesser.

1.1.6 ~~The Sandwich Construction Rules~~ These Rules set down requirements for new construction that in general include a structural design as described in *Ch 1, 3 Structural configuration*.

1.1.6 ~~The Sandwich Construction Rules~~ These Rules also include requirements for overlay construction (*see Ch 1, 2.1 General 2.1.5*) applicable to existing ships. Overlay construction is only to be applied when the gauged thickness after diminution is equal to or greater than the rule minimum plate thickness as defined in *Table 3.4.1 Thickness allowance* (*see also Ch 1, 1.5 Special application*).

1.2 Loading

1.2.1 The ~~Sandwich Construction Rules~~ These Rules are framed on the understanding that ships will be properly loaded and handled; they do not, unless it is stated or implied in the class notation, provide for special distributions or concentrations of loading other than those included in the approved Loading Manual. The Committee may require additional strengthening to be fitted in any ship which, in their opinion, would otherwise be subjected to severe stresses due to particular features of the design, or where it is desired to make provision for exceptional load or ballast conditions.

1.3 Advisory services

1.3.1 ~~The Sandwich Construction Rules~~ These Rules do not cover certain technical characteristics, such as stability, trim, vibration, docking arrangements, structural fire protection, etc. The Committee cannot assume responsibility for these matters but is willing to advise upon them on request.

1.6 Interpretation

1.6.1 The interpretation of the ~~Sandwich Construction Rules~~ these Rules is the sole responsibility and at the sole discretion of LR. Where there is any doubt regarding the interpretation of the ~~Sandwich Construction Rules~~ these Rules it is the ~~builder's~~ Builder's and/or designer's responsibility to obtain clarification from LR prior to submission of plans and data for design appraisal.

1.6.2 Where applicable, ~~the Sandwich Construction Rules~~ these Rules take into account unified requirements established by the International Association of Classification Societies.

■ *Section 2*
Definitions and structural terms

2.1 General

2.1.1 For the purpose of clarifying the nomenclature of items of structure referred to throughout ~~the Sandwich Construction Rules~~ these Rules, unless expressly stated otherwise, the terms used herein have the meanings defined in the following definitions, *see also Pt 3, Ch 3, 1.1 Application 1.1.1* of the ~~Rules for Ships~~ *Rules and Regulations for the Classification of Ships*.

■ *Section 3*
Structural configuration

3.1 General

3.1.1 Requirements are given in ~~the Sandwich Construction Rules~~ these Rules for ships constructed either fully or partly of sandwich panels.

■ *Section 4*
Rule structural concept

4.1 General

4.1.1 ~~The Sandwich Construction Rules~~ These Rules are formulated to provide for scantling derivation for designs where the sandwich panel forms the flange of the primary members, *see Pt 3, Ch 3, 3.2 Geometric properties of section* of the ~~Rules for Ships~~ *Rules and Regulations for the Classification of Ships*. Details of the requirements are given in *Ch 3 Design Basis for Panels* and *Ch 4 Design Basis and Scantling Determination of Primary Structure*.

4.1.2 Scantling requirements in respect of miscellaneous items of structure such as local foundations, base plates, insert plates, bollards, etc. are not specifically indicated within ~~the Sandwich Construction Rules~~ these Rules. However, the acceptance of such items will be specially considered on the basis of experience, good practice and direct calculation where appropriate.

■ *Section 6*
Information required

6.1 Plans to be submitted

6.1.3 Plans covering the following items are to be submitted:

(b) When ~~Sandwich~~ sandwich construction has been utilised partly, the exact extent and location are to be indicated on all relevant plans.

6.2 Submission of direct calculation

6.2.1 Direct calculations may be specifically required by ~~the Sandwich Construction Rules~~ these Rules or may be required for ships having novel design features or may be submitted in support of alternative arrangements and scantlings.

Chapter 2
Material Manufacture and Construction Procedures

■ *Section 1*
General requirements

1.1 General

1.1.1 Steel ~~Sandwich Materials~~ sandwich materials used for the construction or repair of marine structures which are classed or certified or are intended for classification or certification by LR, are to be manufactured, tested and inspected in accordance with the ~~Rules for Materials~~ *Rules for the Manufacture, Testing and Certification of Materials* and ~~the Sandwich Construction Rules~~ *Rules for the Application of Sandwich Panel Construction to Ship Structure*.

1.1.3 Non-metallic core materials are to be applied, tested and certified in accordance with this Chapter of ~~the Sandwich Construction Rules~~ these Rules.

1.1.4 The methods of construction are to be in accordance with ~~the Sandwich Construction Rules~~ these Rules.

■ *Section 2*
Core material

2.5 Material testing

2.5.2 The ~~builder~~ Builder of the sandwich panels must mix the individual components of the elastomer under controlled conditions and measure the following properties according to recognised standards to a schedule acceptable to LR:

■ *Section 3*
Panel manufacturing process

3.5 Preparation for cavity injection

3.5.2 The cavity formed by the steel plates and perimeter bars is to be air tight. Air tightness is to be demonstrated to the Surveyor's satisfaction, according to a mutually agreed schedule, prior to elastomer injection. When this test is performed, the procedure given in *Pt 3, Ch 1, 9.6 Leak test procedures* of the ~~Rules for Ships~~ *Rules and Regulations for the Classification of Ships* are to be followed with the exception of that relating to the air pressure. It is recommended that the air pressure be raised to ~~0,2 bar (0,2 kgf/cm2)~~ 0,02 MPa and kept at this level for about one minute. Any failed welds are to be repaired and retested.

■ *Section 5*
Typical design details

5.2 Application

5.2.1 The detail designs provided in this Section are applicable to all ship types covered by ~~the Sandwich Construction Rules~~ these Rules.

Chapter 3
Design Basis for Panels

■ *Section 1*
General

1.2 Equivalent requirements

1.2.1 LR will consider direct calculations for the derivation of scantlings as an alternative and equivalent to those derived by ~~the Steel Sandwich Construction Rules~~ these Rules requirements.

■ *Section 2*
General

2.2 Watertight and deep tank bulkheads

2.2.2 The steel sandwich panel for watertight and deep tank bulkheads is to be dimensioned such that the requirement below is satisfied:

where
h_4 = *see Table 1.9.1 Watertight and deep tank bulkhead scantlings* in ~~Pt 4, Ch 1~~ *Pt 4, Ch 1 General Cargo Ships* of the ~~Rules for Ships~~

■ *Section 3*
Panel scantling requirements – decks loaded by wheeled vehicles

3.1 Application

3.1.1 ~~The requirements of this Section cover decks loaded by wheeled vehicles and are in addition to the requirements in~~ ~~*Pt 3, Ch 9, 3 Decks loaded by wheeled vehicles*~~ ~~of the Rules for Ships with the exception of 3.4.1 to 3.4.3 and 3.5.~~
The requirements of this Section cover decks loaded by wheeled vehicles and are in addition to the requirements in *Pt 3, Ch 9, 3 Decks loaded by wheeled vehicles* of the *Rules and Regulations for the Classification of Ships* with the exception of;

- *Pt, 3, Ch 9, 3.4 Deck plating 3.4.1*,
- *Pt, 3, Ch 9, 3.4 Deck plating 3.4.3*,
- *Pt 3, Ch 9, 3.5 Deck plating longitudinals and beams.*

3.2 Decks loaded by wheeled vehicles

3.2.2 The bending stress, σ_b, in the panel subjected to wheeled vehicles is to be taken as:
$\phi = \frac{500}{m}$ where the wheel load is assumed to be adjacent to the girder, *see* ~~Fig.3.3.1~~ *Figure 3.3.1 Diagrammatic illustration of wheel load location and size*

■ *Section 4*
Panel scantling requirements

4.3 Taper requirements

4.3.1 The scantlings of the steel sandwich panels are to taper gradually from the midship region to the fore and aft ends, *see Pt 3, Ch 3, 2.5 Taper requirements for hull envelope* of the ~~Rules for Ships~~ *Rules and Regulations for the Classification of Ships*. Where it is proposed to taper from steel sandwich panel construction to single steel construction the rule thickness should be used as the basis for the tapering (~~$t_c = t_{rule}$~~ $t_c = t_{rule}$), *see Ch 3, 4.4 Thickness of sandwich panel 4.4.3* for the calculation of ~~t_{rule}~~ t_{rule}.

4.4 Thickness of sandwich panel

4.4.1 The thickness of the top and bottom plates and core of the steel sandwich panel is to be determined, as shown in *Figure 3.4.1 Determination of equivalent scantlings* t_{rule} *and* Z_{rule} and in the following paragraphs, on the basis of the equivalent scantlings given in the ~~Rules for Ships~~ *Rules and Regulations for the Classification of Ships* (~~t_{rule}~~ t_{rule} and ~~Z_{rule}~~ Z_{rule}).

4.4.3 The equivalent rule thickness, ~~t_{rule}~~ t_{rule}, is to be calculated in accordance with the appropriate chapter for the particular ship type. For example, the equivalent rule thickness t_{rule} , for the bottom shell of a ~~General Cargo Ship~~ general cargo ship is to be calculated from *Table 1.5.2 Bottom shell and bilge plating* of the ~~Rules for Ships~~ *Rules and Regulations for the Classification of Ships*.

4.4.4 The equivalent section modulus, ~~*Zrule*~~ Z_{rule}, of secondary member is to be calculated in accordance with the appropriate chapter for the particular ship type. For example, the equivalent section modulus for the bottom shell longitudinals of a ~~General Cargo Ship~~ general cargo ship is to be calculated from *Table 1.6.1 Shell framing (longitudinal)* in *Pt 4, Ch 1, 6 Shell envelope framing* of the *Rules and Regulations for the Classification of Ships*.

4.4.5 In the calculation of ~~*trule*~~ t_{rule} and ~~*Zrule*~~ Z_{rule} the material factor is always to be taken as $k = 1$ and the spacing is always to be taken
as $s = 700$ mm.

■ *Section 7*

Buckling

7.2 Derivation of the buckling stress for steel sandwich panels

7.2.1 The critical compressive buckling stress, ~~σ_E~~ σ_{E}, for a steel sandwich panel subjected to uni-axial in-plane compressive loads is to be derived as follows:
where
t_{corr} = standard deduction for corrosion, *see* *Table 4.7.1 Standard deduction for corrosion, d t* in Pt 3, Ch 4 of the ~~Rules for Ships~~ *Rules and regulations for the Classification of Ships*

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